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ABSTRACT

This paper focuses on Steve, a high school science teacher, and his philosophy, including his beliefs and practices, over a 1.5-year period in an attempt to understand his change process--how his beliefs changed as a result of his dissatisfaction with his teaching practices. The paper shares this teacher's struggle with change and his transition from teacher as knowledge giver to teacher as facilitator of student learning. The paper also illustrates the factors which affected Steve's change process, presents a theoretical model of teacher change constructed from his perspective, and suggests necessary components which facilitate teacher change. Finally, the paper shares the importance of the empowerment Steve has gained and how it has influenced his science instruction. (TAH)

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TEACHER EMPOWERMENT THROUGH CHANGE: A CASE STUDY OF A BIOLOGY TEACHER

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PURPOSE

This paper will focus on Steve, a high school science teacher, his philosophy including his beliefs and practice, over a one and a half year period, in an attempt to understand his change process - how his beliefs changed as a result of his dissatisfaction with his teaching practices. It will share this teacher's struggle with change and his transition from teacher as knowledge giver to teacher as facilitator of student learning. The paper will also illustrate the factors which affected Steve's change process, present a theoretical model of teacher change constructed from his perspective and suggest necessary components which facilitate teacher change. Finally, the paper will share the importance of the empowerment Steve has gained and how it has influenced his science instruction.

INTRODUCTION

Science education today is experiencing a major crisis. Predominant and current behaviorist views of knowledge and content-oriented approaches to the learning and teaching of science which rely heavily on textbooks are failing to generate a scientifically literate society (Duschl, 1988; Fleury, 1989; National Science Board, 1983; Tobin & Jakubowski, in press) and to foster interest and inquiry, and emphasize relatively isolated pieces of knowledge. Educators are failing to bring about a significant change in students' learning with understanding (Kuhn, 1970; von Glasersfeld, 1989). Recommendations for the improvement of education are calling for a restructuring in the way we think about knowledge and in our approaches to science teaching.

A viable solution to our educational struggle is a revolution in philosophical views of knowledge resulting in a shift from the present behaviorist paradigm and its concern with observable behaviors to a constructivist paradigm and its concern with meaning and understanding (Bodner, 1986; Fleury, 1989). According to the constructivist epistemology, learning is a personal constructive process generated from individuals' interpretations of the world around them using their senses and prior experiences. As such, knowledge resides in the individual and is constantly being tested and modified throughout ones' experiences. Because of the belief that knowledge is personal, the research technique is qualitative and focuses on the teacher's perspective as he or she tries to make sense of the world of teaching.

Tobin and Jakubowski (1989) suggest that reform efforts need to address the necessity for teachers to restructure their roles in teaching and learning, thereby changing the nature of classroom learning environments in science and mathematics classes. Instead of viewing knowledge as a commodity that teachers can pour into students' heads, constructivist teachers help students create ideas, free up their over-used memory, and facilitate student learning with understanding. In addressing

calls for reforms and in reconceptualizing and developing new reform strategies, it is imperative that we keep teachers at the center of this reform. Past educational reform movements have shown that "top down" reforms have little impact on classroom teachers (Carnegie Foundation, 1983; National Commission on Excellence in Education, 1983; Shaw, Davis, & Sidani-Tabbaa, 1990). In the final analysis, it is the classroom teachers who implement the curriculum, adapt it to the needs of their students, and project it through their individual styles. Thus in trying to implement reform, we must be cognizant of teachers and pay close attention to their philosophical perspectives. By keeping teachers at the center of all educational reform and directing our attention toward understanding teacher beliefs, their impact on practice, and understanding the process of teacher change, we can better affect change in classrooms and schools, and thus improve education.

Teacher Beliefs

In studying teacher change from a constructivist perspective, the importance of examining and understanding teacher beliefs cannot be overemphasized. Beliefs are not viewed as observable or easily examined as was done under the behaviorist paradigm. Rather teachers' own beliefs, observations, and perceptions about teaching form a basis for understanding the teaching environment and direct the process of change. Research shows that teachers' beliefs about learning and teaching have a direct impact on classroom practice (Jakubowski & Tobin, 1990; Pope & Gilbert, 1983; Tobin, 1988) and on the way the curriculum is implemented (Davis, 1989; Sidani-Tabbaa, 1989).

Analysis of a teacher's beliefs is a difficult task. Since beliefs are not observable and not easily examined, some interpretations of them can be constructed using repeated classroom observations and close analysis of conversations and word usage. Such an analysis is in no way a complete description of the teacher's beliefs. However, it can provide an insight into the metaphors the teacher uses to make sense of his or her experiences (Lakoff & Johnson, 1980). Consequently, the metaphors used to make sense of the main teaching roles can be the focus for reflection and change, as change implies reconceptualizing roles and associated beliefs.

Teacher Change and Empowerment

Teaching is an activity which has to do, among other things, with the modification and formation of belief systems. If belief systems were impervious to change, then teaching, as a fundamental method of education, would be a fruitless activity. Teaching can be described as an unending effort to reconstitute the structure of our ways of believing- the effort to reorganize our systems of beliefs (Green, 1971, p. 48). Reflection, according to Shulman (1986), is a set of processes through which a professional learns from experience. As teachers reflects upon their own experiences, they review their own performance in light

of the purposes of the lesson, which may lead to a new comprehension of the material or new insights about their students.

Furthermore, Freedman, Jackson, and Boles (1983) showed that when teachers exercise responsibility for their own growth, the expected outcomes are increments in cognitive growth, positive self-concepts and, most importantly, a feeling of power over one's own learning. Change has to be initiated by teachers who are directly affected by and struggling with the curriculum, textbooks, teaching methodologies, and their role in assisting student learning with understanding.

Teacher empowerment as defined in this paper is when teachers realize that it is within their control to shape the classroom and curriculum, and therefore, make choices to change their own teaching practices. This autonomy does not come without responsibility for empowered teachers also realize that they no longer can place the blame for failure on outside factors.

METHODOLOGY

This study is the result of a year and a half research project with one teacher in order to develop a clearer understanding of his change process. The method of inquiry for the study is the case study method. The strength of the case study method is that it allows the researcher to concentrate on a specific context or situation and to identify, the various interactive processes at work (Goetz & LeCompte, 1984). Data sources included transcriptions of teacher interviews-formal and informal, classroom observations, videotapes, fieldnotes including comments from research meetings, and the teacher's journal.

Category coding (Miles & Huberman, 1984) was used as a method of data reduction. Data was classified according to important or recurring themes. Constant comparison (Goetz & LeCompte, 1984) was used for theory generation.

After the data were gathered, analyzed, and assertions were formulated, meetings were scheduled with Steve to discuss the findings. This provided further data as it allowed the researcher to gain insights into the change process from Steve's perspective as he reflected on the analysis.

TEACHER BACKGROUND

At the time of this study Steve had twenty-two years of teaching experience at both the middle and high school levels. He was teaching biology at a large high school in a mid-sized southern city. Steve had received numerous awards and recognitions for his teaching including the state science teacher of the year. He was very active in local, state, and national professional organizations. Steve was also enrolled in a masters degree program in science education and was part of a university directed research project called the Enhancement of Mathematics and Science Teaching (EMST) project.

Having been brought up, educated, and trained in a behaviorist, realist, and teacher-centered paradigm, Steve's beliefs were greatly influenced by and reflected the traditional philosophy under which he was taught. At the beginning of the study, Steve viewed knowledge from a realist perspective. He believed knowledge existed as a separate entity outside of one's body and mind and that there was such a thing as truth and reality out in the world that one can know. This belief was reflected in Steve's actions and role as a teacher. He metaphorically viewed knowledge as something that could be transmitted from himself to his students. This was evident when he talked about knowledge, concepts or ideas as residing in books and himself. He used terms such as "covering the concepts" or "giving students background Knowledge."

Teaching methods.

Analysis of teacher interviews and classroom observations revealed teaching methods that relied mainly on lecture and a strong emphasis on content recall as a measure of student learning.

Steve's role was teacher as source or giver of knowledge along with the textbook. This was reflected by his use of lecture as the main mode of instruction. Thus, Steve tended to expect students to listen and to "absorb information" while he shared his teacher-made notes with the class. In his well-intentioned efforts to provide his students with the background knowledge he felt they needed, Steve lectured to his students, required that they read the chapter, take notes on it, and answer the questions at the end of the chapter. This also paralleled his belief that scientific facts were valuable information that he needed to teach and "give" to the students. As a result, "covering" the content in the textbook became a goal of teaching in his classes. Discussion sessions were rare, and when they did take place, their content and depth were limited to the few questions in the back of the chapter or the lab notebook. As to testing, Steve mainly used ready-made or teacher-made multiple choice tests which stressed content recall from the textbook or classroom notes provided by himself.

Throughout his 21 years of teaching, Steve continually tried to change his teaching methods as he searched for a better way to teach and enhance student learning. He was not a so-called "traditional" teacher because he was not satisfied with the status quo. He was not happy with the outcome of his teaching and felt he was not reaching many of his students. He saw some problems with the "way things had always been done" and was trying to improve. Consequently, Steve was struggling with many issues including assessment, finding challenging and engaging teaching strategies such as cooperative learning, teaching for understanding, and finding effective questioning strategies.

Student Learning

Student learning and understanding were very important for

Steve. He believed that "students learn based on things that they already know," that "students still have to construct on something they already know, they still have to see value and usefulness in it [learning]." In Steve's opinion, one of the problems in education was that we "give students too many blocks that do not fit." In some cases, the knowledge we attempt to give is inappropriate and is of no use to them and so they do not remember it. Steve believed most students were motivated and learn better when they enjoy what was going on. He said "I think students want to learn and they'll tell you that." However, he attributed students' poor attitudes toward learning to the fact that "many of them are not willing to put forth the effort because they've never been required to. They have been taught that learning is memorizing." He felt they did not place any value on learning and those who were not motivated and did not have the desire to learn would not learn no matter what methods a teacher used. However, he put part of the blame for students' poor attitudes toward school and learning on society's strong emphasis on grades by which a person's achievement, success, and value were measured. He added, "A student will tell you quickly that he doesn't care if he learns or not as long as he gets a good grade, they're so grade oriented. Our society is grade oriented." Steve related students' dislike for and negative attitude toward science to the fact that educators, specifically school teachers, were doing a poor job at getting students' motivated to see a need for science and to enjoy learning for learning's sake. He concluded, "Their image of science is worksheets, bookwork, and that 'it's boring'" and suggested that students' attitudes toward learning could be enhanced by giving them a problem, something that was challenging and new to them, and letting them solve it. He mentioned more than once, "We have to get students thinking." Finally, Steve believed that a very effective way to teach and to promote interest in students was to provide them with opportunities to experience science first hand and he expressed a desire to be able to do that himself.

Despite his success as revealed by his popularity and good reputation, Steve was dissatisfied with his teaching methods and searched for better ways to teach. He felt he was "missing the key to enhancing student learning." He was also disappointed with his students' performance, lack of motivation, and interest in learning.

Constructivism

Steve was introduced to constructivism as a result of his involvement in a masters program in science education which in turn provided him with the opportunity to study current educational research issues in the science education field. He felt the constructivist philosophy was not new to him and stated he had "always been a constructivist." Constructivism was a piece of the puzzle as it "fit with" some of his ideas about the nature of knowledge, "made sense" to him, and was a viable alternative explanation of how students construct knowledge. In

addition to having provided Steve's belief system with the support that it needed, constructivism was an additional perturbation for Steve and caused him to further reflect on and examine his beliefs. Close study of Steve's interviews and classroom observations revealed that Steve had subsumed only parts of constructivism as his philosophy including his beliefs about knowledge, teaching, and learning were constraints on his change process.

FINDINGS

The study's findings will be presented in the form of three primary assertions which arose from the data.

Dissonance in Beliefs

Assertion 1: **There was a dissonance between Steve's stated beliefs and his practical beliefs about the nature of knowledge, teaching, and learning.**

In this study, stated and practical beliefs were defined in the following manner. Stated beliefs represented the ideal or theoretical beliefs Steve professed and were related to what he would like to see in his classroom. Practical beliefs were inferred from his practice and represented what he actually did in his classroom.

As a teacher-in-transition, Steve had developed a dichotomy or a lack of congruence between his stated beliefs and his practical beliefs. In talking about the nature of knowledge, his teacher role, or student learning, Steve's stated beliefs reflected the constructivist philosophy. His teaching, however, as observed in the classroom, revealed that Steve operated from a behaviorist perspective. As a result, his deep-seated, traditional, and behaviorist beliefs guided his actions and practice.

In talking about the nature of knowledge and how students learn, Steve stated knowledge was constructed by students using their own prior experiences to make sense of new experiences. He said, "Students learn based on things they already know. . . . They have to construct on something they already know." He also stated that students learned best "by doing" and when they valued and saw the usefulness or relevance of what they were learning to their lives. However, his teaching methods reflected quite the opposite.

Metaphors

Analysis of data revealed several metaphors Steve used in talking about and describing his teaching. Analysis of these metaphors and beliefs showed an evident lack of congruence between Steve's beliefs and practice.

Close analysis of Steve's teaching strategies revealed that Steve still used the conduit metaphor (Lakoff & Johnson, 1980) when talking about knowledge. He viewed knowledge as something that was given, transmitted, transported, or sold as a commodity. This was also evident in his "salesman" metaphor

where he talked about himself as "selling students on biology."

For example, a primary metaphor Steve used to describe his teaching was the "teacher-in-the-driver-seat" metaphor. Steve described his role in the classroom as "being in the driver seat" and when the researcher pressed him to elaborate he compared his teaching role to a bus driver "steering the kids on the right road to knowledge." As to his teaching, he compared it to a "bus which was the students' vehicle on the road to learning." He added,

> The motivated students are on the bus, the ones that are not and who become motivated during the year are the hitchhikers you [the teacher/bus driver] pick up along the way . . . motivation is their ticket to ride.

Thus, as students became motivated, they were "picked up" and joined the others "on the road to knowledge."
Other metaphors included "teacher-as-salesman," "teacher-as-disciplinarian," and "teacher-as-dad."

Many of the metaphors Steve used in teaching related to him being the center of the action, in control of the classroom, teaching, and learning. They also reflected his beliefs about knowledge being a commodity and revealed the dissonance between Steve's stated and practical beliefs.

Practice

In teaching, Steve held the pervasive belief that the teacher should be in control of teaching. This practical belief in turn permeated other beliefs. Despite his efforts to change his teaching role, Steve operated from a control model and struggled to relinquish control of the classroom.

During formal and informal interviews, discussions in his graduate courses, and research meetings, Steve stated that as a result of learning about constructivism, he was more concerned about "teaching for understanding" than he was before.

However, analysis of classroom observations and a videotape revealed that content recall not understanding was stressed as a goal of learning and confirmed that Steve was a teacher in control of both teaching and learning. He frequently used lecture-type methods to provide students with what he called "the necessary background knowledge" which he believed they needed before they could learn. Steve's control of the class was manifested by his control over the discussions and question and answer sessions and by his reliance on target students. A definite pattern was apparent in Steve's classes during "discussions": teacher asked a question, waited, asked a particular student to answer, student answered, teacher repeated the answer, elaborated on it, then went on to the next question. This pattern was evident except during laboratory and cooperative learning activities where Steve's role seemed to change to questioner.

Consequently, Steve's perceived weaknesses were consistent with his practical belief that the teacher should be in control of the classroom including what students learned and how they

learned it, and that the teacher must be present in order for "real" learning to occur. Steve's idea of "facilitating" was still by "giving." The fact that he continued to use the giving or giver metaphor implied that the teacher was the one deciding what students learned. In addition, even though Steve said that most students were motivated and learned better when they enjoyed what was going on, he nonetheless put the responsibility of doing this on himself and decided what the students were going to learn for them. There was an obvious dichotomy between what Steve stated he wanted for his students which was to be responsible for their own learning, and his practical belief that his duty was to be the source of learning. In doing so, Steve was getting "caught up" with his role as teacher as giver of knowledge, and in control of how and what students learned.

Summary

Although Steve stated that his main concern was student learning, in practice, it was evident that he was unable to relinquish his control of the learning environment. He would have liked to view his teacher role as friend, motivator, questioner, and moderator of discussions and learning. However, his instruction reflected his practical beliefs that the teacher, along with the textbook, was the source of knowledge.

Perceived Constraints

Assertion 2: **Steve's perceived constraints were a major source of his dissonance and acted as obstacles to his change process.**

Constraints are beliefs that teachers hold about obstructions to the attainment of their ideal. The following section explores Steve's constraints and the impact they had on his teaching practices and his change process.

Constraints are a type of belief which can be internally or externally imposed depending on one's perceptions of the source of the constraint. The resistance to change was not an overt act but more covert and subconscious. Steve's constraints acted as barriers to his change process and to teaching the way he wanted to or felt he ought to; some he perceived as from within and some as external to himself. Two qualitatively different types of constraints, structural and cognitive, are discussed.

Structural constraints are constraints perceived by the teacher as being imposed on them from an external source, such as the administration, whereas cognitive constraints are internally imposed, coming from within. An example of a cognitive constraint is when the teacher knows what he or she should be doing, but does not know how to go about improving his or her instruction because of a lack of images from which to select alternatives (Shaw, Davis, & Sidani-Tabbaa, 1990). Steve talked about his constraints as being his own constructions. He stated that most of his constraints were cognitive and acknowledged that he sometimes used them as excuses to cover his misgivings or for not doing something. Steve also acknowledged that some of these

constraints were directly related to his struggle to change, his resistance to change, his wanting to cling to the past, and his search for a better way to teach. Examples of cognitive constraints included his behaviorist background, his past successes, the intrinsic rewards he valued so much from students, his lack of alternative images, lack of time, preparation, and his busy schedule. As to his structural constraints, Steve viewed them as aggravations that had to be dealt with. They were constraints on teaching, however, they also had an impact on his change process. Examples of structural constraints Steve perceived include: curriculum, administrative pressures and time, assessment, poor student attitudes, and lack of resources.

Steve's constraints had a substantial impact on how he changed his beliefs and practice. The next section also examines how Steve's constraints impacted his practice and how he changed and tried to overcome them.

Requisites for Change

Assertion 3: **Teacher change is a gradual process which requires a feeling of dissatisfaction with practice, an awareness of a need to change, commitment to change, a new vision, reflection, substantial time and understanding, as well as a feeling of empowerment.**

Steve's change process started along with his teaching career. He did not consider himself a traditional teacher because that implied he was satisfied "with the way things had been done" and he was not. He said,

> I've never been a traditional teacher, but I'm too traditional to suit me. I can't remember a time in the past 21 years when I had not been in transition, because I'm always trying something different.

Midway through the study, Steve and I, with the purpose of reflecting back on his change process, developed a model of teacher change which we both negotiated and agreed was representative of what Steve had experienced in trying to change. In the following section, Steve's model of teacher change is used as a framework to explicate and discuss his change process - why and how Steve is making the transition from teacher-directed instruction to student-centered learning and from behaviorism to constructivism.

Steve's Model of Teacher Change

Steve's change model included six components which he felt were necessary for change: disturbance; realization of a need to change; commitment to change; vision; implementing the vision; and making changes. Other issues that are explored include: what problems Steve faced during this transition as he tried to reconceptualize his roles, and reflect on and attempt to change his beliefs and practice.

Disturbance

Steve's dissatisfaction with practice stemmed from his

feeling that he was doing a "mediocre" job. His students' lack of understanding made him feel that he was not reaching a good portion of the students and not giving them that "spark," that "motivation" that he felt made them want to learn and enjoy learning. He added, "When students are not engaged and think the material is 'boring,' then there is something I'm doing wrong." This feeling of dissatisfaction with his teaching methods set against the image that he believed faculty members and students had drawn of him as a well respected and exemplary teacher exacerbated Steve's feeling of inadequacy. He said,

> It has always annoyed me that I'm considered one of the top teachers when I feel I'm only doing a mediocre job. That irritates me because to me, there should be exemplary teachers out there that are so much better than me.

Other disturbances which added to Steve's feeling of dissatisfaction included, (a) his involvement in this research study, as he read drafts of this thesis and saw himself from a different perspective; (b) his introduction to constructivism via his graduate courses and his involvement in the EMST Project as a coordinating teacher both of which provided Steve with a collegial, collaborative learning environment and alternatives, as he worked and negotiated ideas with other teachers; and (c) having a student teacher in his classroom caused Steve to reflect more on the meaning of constructivism and on his own understanding of this epistemology. All of these events were disturbances which caused Steve to reflect even more on his teaching practices and to question and examine himself more deeply.

Realization of a Need to Change

According to Steve, "One has to feel a kind of frustration or dissatisfaction with what he or she is doing before the need to change is there." Steve's own realization that he needed to change came first as a result of his reflection on his practice. His teaching methods were not allowing him to help students value learning or see a need for it. The constructivist philosophy provided him with an alternative vision of how knowledge is constructed, how students learn, and the role of the teacher in the learning process. Basically, constructivism was a whole new way of looking at the world of teaching, learning, and the classroom environment. Along with his graduate courses, the EMST Project provided Steve with the opportunity to communicate and share his ideas with other teachers, reflect on his teaching practices, and negotiate alternative and better ways of teaching and achieving his vision. Therefore, the communication, collaboration, and most importantly, reflection on his own and with colleagues caused Steve to become more aware of his need to change and his desire to change.

Commitment to Change

Steve believed his commitment was to change and to become a constructivist teacher. He felt that "a commitment to change is

a natural process in our constant quest for improvement." For a long time, he had wanted to change but was stuck. However, having been made aware of alternative ways of doing things, via his graduate courses and his introduction to constructivism, helped Steve make the commitment to change.

According to Steve, in order to change one has to see a need and value in something before one can change his/her beliefs and be willing to put forth the time and effort and then commitment can be made. He added, "Changing is not easy but I am committed to change and I know it will be for the better."

Summing up the importance he felt the teacher's commitment to change played in his own change process, Steve said,

> I felt a need to change when my students didn't understand basic biological concepts and still made A's and B's. I realized that there needed to be a change, and I wanted for there to be a change, and I think that's the only way that a teacher is going to change. Because if a teacher doesn't want to and doesn't see a need for change, there will be no change.

Vision

Steve's vision of a good high school science teacher was (a) a teacher who cared about his/her students and education; (b) a teacher who was not only willing to try new things but one who was constantly searching for new ideas, new methods of teaching, not teaching the same way in every classroom or from year to year; (c) a teacher who was not afraid to let his/her students investigate and explore ideas, and one who set up activities so the students can explore, experiment with, and understand concepts rather than reading about them in books and memorizing facts; and (d) a teacher who was professional, willing to spend his/her own time on education, not a nine-to-five worker.

Steve's vision of the teacher's role was the teacher as moderator of the classroom and the activities. The teacher was someone who kept students on track and encouraged them to express their knowledge and to work toward learning with understanding. Someone who was constantly trying to get students to see the relationship between what they were studying and their world. He also believed that "students must be allowed to take responsibility for their own learning. I really know that this can be a reality. I just haven't found the key yet."

At the beginning of the study, Steve's vision was not clearly defined. Via his graduate courses where he was presented with alternative theories of knowledge and specifically constructivism, his vision became clearer. His involvement in the EMST Project, provided him with more images from which to choose. The collaboration and reflection among teachers provided a richer environment in which Steve could test his ideas.

Implementing the Vision

In the last section the fact that Steve's vision of the ideal classroom had not become reality is illuminated. In his

classes, Steve was still at the center of the teaching, as he put it "in the leadership position, the questioning position, the teacher position," and many of the students were in their seats not "on the edge of their seats", bored not "excited", and not interested in learning. In reflecting on his teaching methods, Steve felt he was still clinging to the old traditional ways.

Steve believed his constraints were barriers to his change process and added to his struggle with change. The constraints seemed to come to life when he tried to project himself into his vision. He realized part of his problem lay in his teaching methods, that he not only didn't make learning fun but he didn't know how. He said, "I want the kids to enjoy learning and I don't really know how, I try different things that I think might be good but when I try them with the kids they don't work." Although he thought the key to successful teaching in science was problem solving, he found it frustrating to find challenging problems which the students would want to do. He concluded saying, "What I perceive as a good problem the kids don't." He lacked the problems and activities that would challenge his students and get them engaged.

Steve also believed he was lacking the knowledge, experience, and access to alternative images about constructivist teaching. He wanted to observe someone who could do what he saw as his vision and "learn how by seeing examples." He expressed this desire by saying, "I think I can learn something and make it work but I can't find anybody like that. . . . I would like to see somebody else teach biology, I've never observed anyone else teaching biology."

Making Changes

In this section, Steve's changes are presented and discussed. Changes and major events which had a strong impact on his teaching practices are highlighted and presented as subsections. Steve had to first make changes in his way of thinking about teaching, cognitive changes, before he could make observable, overt changes in his teaching.

Cognitive changes. In reflecting on the changes Steve perceived he had made as a result of his return to continue his graduate studies in science education and his learning about the constructivist theory of knowledge, Steve remarked,

> It's difficult for me to see the difference and although I know that I've changed, I don't think there have been any drastic changes, because I've always tried and I'm always trying new things and searching out better ways.

However, Steve felt he was "more of a constructivist" today than he was before. He said,

> I used to say "before you can teach students" and now I say "before students can learn." Right there, I see a difference in my philosophy of learning and teaching. Before, I felt that I needed to provide students with some background knowledge. The more I thought of constructivism, the more I was conscious of looking for ways to help

students construct their own knowledge and the less explaining and lecturing I found myself doing.

As to the changes he made in his role as a teacher, Steve said,

> I've gone from being the person that was trying to give knowledge by almost pouring it into the students' heads to where I'm allowing the students to construct their own knowledge and background. I'm trying to be more of a mediator or moderator of a discussion, a questioner rather than a provider of knowledge.

He went on to say,

> I believe that a teacher's role is to promote and facilitate student learning and understanding by helping students to understand scientific concepts and to help them explore new concepts using any method that works instead of thinking that my job is to provide students with a good education, I now believe that they have to be responsible for their own learning and a teacher is a guide or promoter of understanding.

Finally, the changes that Steve said that he would like to see himself make are to use a lot more discovery-type activities that are challenging yet not too difficult and activities that lend themselves to cooperative learning. He envisioned students working together in small groups of two or three students, as optimal opportunities for students to learn and share from one another, where they can communicate and negotiate answers and help each other understand. This would also put the educational responsibility on the students rather than the teacher. Steve did not feel that more laboratory periods were the answer, but that he was searching for laboratory activities that involved problem solving and that would be interesting to the students so as to get them engaged. He summed up his comments by saying, "Activities that involve hands-on and minds-on, that students have to think about in order to solve." Steve's frustration was rooted in the fact that only fifty percent of his students were engaged and the rest were not interested in learning. Steve's involvement with the EMST Project encouraged him to use more cooperative learning activities as a possible way to allow students to work together and construct knowledge on their own.

Observable changes. Specific observable changes Steve made can be categorized as becoming more student-centered, using more cooperative learning, changing questioning strategies, and changing assessment strategies.

Steve changed by trying to make his teaching more student-oriented and by putting the responsibility of education on the students. He explained,

> Before, my students took lecture notes and answered questions at the end of the chapter, now, I have them read the chapter, take notes on it, and allow them to use their notes in classroom discussions while I used my own questions instead of the book's.

In this way, Steve felt the students' notes were the background knowledge he believed they needed to construct new knowledge.

Although Steve pointed to the fact he was still searching for a better way of getting the students to construct their own knowledge and to get them more involved, he felt this was his present strategy.

Reflection on this change and on Steve's usage of the above teaching strategy revealed Steve's realist belief that knowledge was in books. The change Steve made was that he changed the source of knowledge from himself to the textbook. Instead of him lecturing, he now expected the students to read the textbook, take notes from it, and use those notes, of which they now had more ownership, during classroom discussions. This change is one example of how Steve has subsumed and adopted parts of constructivism as a first step to change.

When asked how the changes and his new role have affected his practice, Steve believed he was more conscious of his students' needs, he expected more out of his students, and he put more responsibility on them for their learning. This, in turn, allowed him to spend more time planning and reflecting on his actions. He also added,

> I've noticed that instead of just looking for an activity to do, I think more about how that activity will develop understanding. I want my students to be excited about the activities and to be looking forward to the next ones.

Cooperative Learning. Examining changes Steve made through his use of cooperative learning, he changed the way he structured his class. He tried to make his labs more problem-centered and more cooperative. He began using cooperative activities that were not labs and was seeing some success. Steve viewed cooperative learning as a method that lent itself well to constructivist teaching practices. It was a challenge in that it was a new way for him to: teach for understanding, achieve student participation, and take the role of moderator or questioner. Steve believed students learn better if the material is presented by their peers. By using group activities, Steve tested his idea and attempted to place the responsibility of learning on the students instead of on himself. By providing the opportunity for each student group to present a portion of a lesson or concept, Steve tried to facilitate students' participation in the learning process. He also observed a lot of negotiation and communication going on during group work. Although Steve felt that planning for cooperative activities required more preparation time, he hoped to continue adding more activities in his classes as the year progressed.

Questioning Strategies. Steve changed his questioning strategies from asking for specific responses to trying to discover what students know. He explained,

> I would ask a student that I knew knew the answer to a question and they couldn't answer it. What I was doing, I was asking them so specific, the kid may have known everything else about that particular subject except that one thing that I was asking, so all of a sudden the kid doesn't know how to answer it.

Now, instead of saying "tell me a specific answer", Steve said "tell me what you know about this" or "tell me something about this topic" then if the student knew anything at all, they were successful. Steve felt this may not be the "best constructivist way of doing it" but that "it's a step in that direction." This was another way Steve was using to put some responsibility and decision-making on the students in deciding what is important and what they want to learn.

Assessment. One change Steve wanted to make was to incorporate assessment techniques that he believed would better indicate understanding in his students such as essay-type questions rather than multiple choice questions. His aim was "to do testing that students can relate to more" and to find out what the student knew rather than what the student did not know. He said, "It's easy to find out what a student doesn't know . . . but to get at finding out what the students do know and what they do understand that is the key to evaluation." [Steve's emphasis] He further explained,

> I have seen that the greater variety of experiences a student has, the better he or she will understand the concepts. I have also realized that because a student does not understand the "correct answer" does not mean he or she does not understand what is going on.

Condensing the change process in his own mind, Steve said, "You have to have beliefs first, then the vision, and commitment means that you're going to try to achieve it, change comes from you actually taking action because you can have a commitment and never take any action."

In thinking about Steve's change process, it was difficult to attribute changes which Steve made to specific events and times in his change process. Further analysis led me to conclude that the change process was cyclical in nature. With each disturbance Steve encountered, he stated he experienced and felt he went through the same basic process. Although the process of writing gives the appearance of linearity, Steve said that the process was not always linear in fashion as the requisites in the process were interactive and varied in their order and importance depending on the nature of the disturbance.

Steve's model of teacher change was supported and theoretically grounded when a similar change model emerged from the EMST Project research (Shaw, Davis, & Sidani-Tabbaa, 1990; Shaw & Jakubowski, 1989; Tobin & Jakubowski, 1990). Shaw, Davis, and Sidani-Tabbaa (1990) proposed a model of teacher change which paralleled Steve's model and was composed of: perturbation, awareness of a need to change, commitment, vision, projection into the vision, and cognitive and overt changes with reflection being integral throughout the change process.

Factors which Facilitate Change

From Steve's study factors which facilitated his change process were identified. Collaboration, reflection and the resulting empowerment are discussed below.

Collaboration

Collaboration with and support from others facilitated Steve's change process. For example, he collaborated with another science teacher and his student teacher for the purposes of designing new curricula with "lots of hands-on activities and planning together for the upcoming school year." To achieve his vision, Steve perceived himself learning how to design and implement student-centered activities. He stated that the support he was getting from the research team, his colleagues, his principal and assistant principal were a necessary component for him to reach his vision. Furthermore, Steve felt if the support were withdrawn, he would "probably eventually revert back" to his old, more traditional way of teaching. He then added, "I don't think that I'd ever go all the way back but I think I'd revert back to somewhere in between." He explained further by saying, "If I ever reach the vision that I have of the constructivist classroom, then nothing in the world is going to change [his constructivist teaching methods] unless a better idea comes along that makes me want to change again." Steve said if he ever reached his goal of the constructivist classroom, then he will keep it even if the support was pulled away, however at this point in his change process, he saw himself reverting back to a more traditional way because "it's safe, I can make it work, it doesn't work as well as I might want it to, but it does work."

Reflection

From Steve's change process, reflection proved to be a necessary if not one of the most important requisite for change. Reflection on thoughts in relation to actions and vice versa was the key to change and acted as a catalyst to change. Steve stated,

> I can't imagine teaching without reflection. I keep a day-to-day journal (as of this year). I have always discussed teaching practices and ideas with my fellow teachers. I have only this year begun to observe other teachers' classrooms and to reflect with them on their practices. When I drive across town or across the state, I do not listen to the radio, instead I use the time to reflect upon what I have been doing in education.

Reflecting on his own teaching, Steve questioned his own professional activities including his work with student academic groups. These activities often took him out of school and away from his students. He was concerned about how this affected the learning of his students. He struggled to be in control. Although he felt he needed to be an educational leader in the community and the state, he did not want this at the expense of his students' education. Yet by being involved in the district and state, he had greater enthusiasm for teaching and a greater influence over the direction of science education. Although Steve was aware of his need to change and was committed to change his beliefs and practice by embracing the constructivist

philosophy, he was also concerned about his own progress toward change. He was relieved to hear that his clinging to traditional ways was natural because it takes a long time to change. He also believed that "teacher change is not all the answer. The students have also been trained in traditional methods for 9 to 12 years and they also have to change." He concluded by saying, "For me, it's going to be a gradual type thing, I have to try things and get them to work."

Empowerment

Although it contradicted what he did in the classroom and his usage of the textbook, Steve felt empowered in that he had control over himself and the curriculum. He felt that he had the power to make changes and to teach the curriculum the way he wanted to. He said,

> I don't know of anything that I've ever done in my life that as a waste of time, I look at everything as part of my education. The years I spent selling shoes were invaluable as far as working with people, learning salesmanship.

According to Steve, an additional aspect that enhanced his ability to embark on the road to change and make changes was the notion of teacher empowerment to which he was introduced in graduate courses. For Steve, empowerment meant "I have control over myself and the curriculum. I can teach it anyway I want to. Empowerment was a teacher having control over what s/he does and it might take a while for them to know how to change things." A dynamic quote from Steve using the metaphor of a ladder summed up where he was and his beliefs about empowerment. He stated,

> I don't see a teacher that's empowered as necessarily being at the top of the ladder but rather at the bottom of the ladder realizing that they can climb the ladder and beginning to climb it rather than staying at the bottom, like we see so many doing because it is safer at the bottom of the ladder as you can't fall off. But if you're empowered, you don't mind falling off because you know you have the power to climb again. A teacher with self-confidence and a good feeling about themselves can move mountains. I know that I am empowered in that I know that I can do it, that I want to do it, and that I will.

Professionally, in five years, Steve saw himself in a much stronger role as a leader in science education in the United States. He had many accomplishments and was very proud of them. He felt he was already well known in Florida and he wanted to be really strong in marine science, specifically marine biology. He also wanted to get into the leadership of the National Marine Educators Association. He enjoyed having a dominant role in education in the county and in the state. After finishing his master's degree, Steve was thinking very strongly about getting certified in administration so if the position of science supervisor in his county came open, he would be in a position to take it.

Summary

As a result of his involvement in this study, in his graduate courses and in the EMST Project, Steve became a much more reflective teacher. He was continually thinking about what he did in the classroom and his own philosophy of the teacher/learner relationship. He became more of an experimenter with different teaching strategies, in trying new ideas. He also became much more empowered as he felt he was moving much further from the "norm" of his school. He viewed the EMST Project as a great learning experience as it helped him to reflect on his own beliefs.

DISCUSSION

Steve's case study has added to an understanding of the process of teacher change. In this section, we will discuss what has been learned from Steve's change process and his model of teacher change using Kuhn's (1970) notion of paradigm shifts.

According to Kuhn, paradigm shifts [Change] occur when the rules or theories of the existing paradigm persistently fail to solve the puzzles or problems it defines and thus the paradigm fails to meet the needs and expectations [vision] of its members [the educational community]. This failure in the normal problem-solving activity causes a crisis, a disturbance in the established equilibrium which in turn, results in dissatisfaction with the existing paradigm. Consequently, as a response to crisis, a search for a novel theory or an alternative paradigm that will solve the anomaly and reestablish equilibrium ensues.

Kuhn's description of why and how paradigms shift, closely parallels why and how Steve embarked on the road to change. Confronted with students' lack of understanding, motivation, and interest in learning, Steve was disturbed as he came to realize that the traditional paradigm from which he was operating, mainly behaviorism, was failing to assist him in enhancing student learning with understanding. As a result of his search for a viable alternative, the constructivist epistemology emerged from educational research as one possible theory.

Kuhn's concept of paradigm shifts supports Steve's model of teacher change by pointing to the need for a disturbance as a prerequisite for change. This disturbance, in turn, causes a feeling that something is wrong with practice. The need for a disturbance or perturbation was also supported by von Glasersfeld (1989) who stated that perturbation is one of the conditions that set the stage for cognitive change. In summarizing Piaget's learning theory, von Glasersfeld (1989) stated, "Cognitive change and learning take place when a scheme, instead of producing the expected result, leads to perturbation, and perturbation, in turn, leads to accommodation that establishes a new equilibrium" (p. 126).

Another prerequisite to change is that teacher change must have a direction, a purpose, and according to Steve's model, a vision. Before any change can occur, teachers need to examine

and reflect on their philosophies about knowledge, teaching, and learning. Once they achieve a basic understanding of their philosophical base, they become more aware of who they are, what their needs are, and thus are better prepared to change. This introspection is necessary to allow teachers to define the direction of their change, to set goals, and to ultimately create their own vision of teaching. For Steve, this process was initiated by his return to continue his studies which presented him with current educational research issues and thus alternatives from which to choose.

Steve's change process has shown that teacher change is a slow, gradual, and difficult process that requires much reflection, time, and understanding.

Closer analysis of and reflection on the nature of the dissonance that existed between Steve's stated and practical beliefs, lead to the conclusion that the dissonance was a natural part of his change process. According to Tobin (1990), embedded in our epistemologies are our beliefs and practices. Thus, as teachers move along a continuum, more toward being constructivists from being realists, first, they start with words, then actions. They test out their ideas, talk about them, try to understand the meanings of the words until they become comfortable with the words or the new metaphors. Then they test them out in practice and thus in actions.

As a teacher-in-transition, the tug-of-war between Steve's practical, "old," traditional beliefs and his stated, "new," constructivist beliefs was a natural part of his change process. He wanted to be and was committed to become a constructivist teacher and tried to project himself into the vision he had of constructivist teaching. However, in practice, Steve could not achieve his vision and experienced more failures than successes. Consequently, he talked constructivism and practiced behaviorism. Steve's stated beliefs represented his attempt at verbally and mentally projecting himself into his vision. These stated beliefs were, in turn, evidence for cognitive changes which were occurring in his mind. As to his actions, they were dominated by his perceived constraints, which were ingrained in his being and which acted as obstacles to him implementing the vision and making overt changes. Steve acknowledged his struggle and the fact that he had many more failures than successes. But as an empowered teacher who was committed to change and determined to realize his vision of a constructivist classroom and teaching, he was not ready to give up.

Kuhn describes the dissonance as being part of the transitional aspect of change. He states that the acceptance and assimilation of the rules of the new paradigm is a gradual process. As a new theory, it has seldom solved more than a few of the problems that confronted it and most of the solutions are still far from perfect. Thus, a transitional phase or period is required, during which time the teacher tests out and questions the viability of the new theory. This, in turn, requires a lot of time and Kuhn calls it "paradigm-testing", "evaluation", and

"confirmation". From Steve's case, "paradigm-testing" or the step of implementing his constructivist vision has been shown to be a very difficult step.

The gradual, transitional, and difficult nature of change was also evident in that although the old paradigm has failed to answer some questions, parts of it and some of its concepts are perceived as still useful. This, in turn, serves to make the transition to the new paradigm more difficult as the old concepts have already been tested. Referring to this point, Kuhn (1970) stated that new paradigms are born from old ones and ordinarily incorporate much of the vocabulary and apparatus, both conceptual and manipulative, that the traditional paradigm had previously employed. But they seldom use them in the traditional way. Within the new paradigm, old terms, concepts, and experiments fall into new relationships; and new theories and concepts become constructed using some of the old ones. Changes are never total as one is still looking at the same world and much of the language, and instruments are basically still the same as before. Consequently, the old paradigm is not totally discarded and the overlap that exists between the old and new paradigm acts as an obstacle to change and keep the teacher from making a complete shift in beliefs.

Steve's perceived constraints acted as such an obstacle to change and made his transition to constructivism even more difficult. Steve's case clearly showed that the more constraints one has the more difficult and the slower their change process will be as the constraints have an impact on every step in the change process.

Further, as an experienced teacher, Steve's commitments to the traditional paradigm under which he was educated and functioned, made it more difficult for him to change. Kuhn (1970) calls this the transfer of allegiance from paradigm to paradigm and says that it is a conversion experience that cannot be forced. Kuhn (1970) adds that the source of resistance that comes with change is the assurance that the older paradigm will ultimately solve all its problems. Steve's clinging to "his traditional ways" and his resistance to change pointed to the idea that there was comfort in being experienced at what he did, it was a routine, even though he knew it didn't best promote understanding. Part of Steve's struggle with implementing his vision and changing was that although the constructivist paradigm was a more viable epistemology in enhancing student learning, motivating students, and getting them interested in learning, this was only in theory. In practice, Steve was having more failures than successes which made it easier for him to revert back to his traditional teaching methods when things didn't go as well as he anticipated. In addition, under the traditional paradigm, Steve was more a leader with a successful image while in the constructivist paradigm he was a student and a follower. Thus, past successes and the familiarity and comfort in what he already knew were other obstacles to change and made his change process even more difficult.

Despite all his perceived constraints, upon reflection and by the end of this study, Steve acknowledged that his constraints were cognitive. He felt they were his own construction and resided in his mind. For Steve, much reflection, much practice, and trial and error assisted him to overcome and learn how to deal with his constraints. As such, in Steve's case, reflection was an integral part of teaching and of his change process. Reflection was pervasive throughout the change process, as it acted as a catalyst for change and enhanced the change process.

Schon (1983), using Dewey's definition, characterized reflection as a specialized form of thinking that arises from doubt and perplexity felt in a directly experienced situation and leads to purposeful inquiry and problem resolution. Whether preparing lesson plans, teaching a new topic, or looking back on a day's events, teachers are constantly reflecting-in and -on their actions and practice. They are faced with numerous and spontaneous decision-making situations on which they must reflect and react. According to Schon (1983), reflection engages practitioners in a "conversation" with the problematic situation and has a cyclical nature that is a fundamental aspect of reflection for new understandings of the situation precipitate further reflection and appreciation. Reflection on practice is a vital part of the change process. This was evident from Steve's study as he became much more reflective due to the learning experiences that perturbed him and assisted his growth and questioning of his beliefs and actions.

Just as reflection has a cyclical nature, Steve's change process, revealed that the process of change also has a never ending cyclical nature. Each step of the cycle is a necessary component to the whole in affecting lasting change. The change cycle also was shown not to be linear in nature as its components are interactive and vary in their importance depending upon individuals' contexts of change. In such a cyclical model, like reflection, disturbances or perturbations are the catalyst or the fuel that ignites the change reaction and keeps it going. Reflection on the disturbance, assists the teacher to assess the need for change. The vision in turn is the teacher's goal and directs the change process. It also keeps the teacher reflecting and checking for congruence between his/her beliefs and practice, and making sure that they [his/her beliefs] match the vision. As the teacher implements the vision, he or she tests out the new beliefs and if they fit the vision then they are internalized. If they don't, they are either discarded or used in a different context. So as one makes changes and experiences successes and/or failures and reflects on those, the vision may change. As the vision changes and is updated, it becomes clearer. In addition, as the new paradigm shows more promise and the teacher begins to experience more successes, this process results in a higher level of commitment, more reflection and more changes. Thus, one's successes and failures can act as perturbations and become the fuel for further reflection and empowerment and keep the cycle going.

Finally, an additional vital element of change that also fueled the cycle for Steve and kept it going was collaboration and support. By becoming involved in the EMST Project, Steve was no longer in isolation. His motivation and heightened commitment came from sharing with other teachers as they looked to one another for new and alternative ways of teaching and became resources for one another. The EMST Project provided Steve with a safe environment in which to ask questions, find alternatives, and be a reflective practitioner.

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